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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of: John Davis Holder   Art Unit: 1722
Serial No.: 10/002,862
Filed: November 15, 2001
Confirmation No.: 4783
For: INTERMITTENT FEEDING TECHNIQUE FOR INCREASING THE MELTING RATE OF POLYCRYSTALLINE SILICON
Examiner: Matthew J. Song

AMENDED APPEAL BRIEF

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December 27, 2006

AMENDED APPEAL BRIEF

This is an amended appeal from the final rejection of the claims of the above-referenced application made in the Office action dated July 14, 2006. The amended appeal brief is filed in response to the Notification of Non-Compliant Appeal Brief dated December 1, 2006. The Notice of Appeal and Appeal Brief fee were filed October 16, 2006. The Commissioner is hereby authorized to charge any under payment or credit any overpayment to Deposit Account No. 19-1345.

I. REAL PARTY IN INTEREST

The real party in interest in connection with the present appeal is MEMC Electronic Materials Inc., owner of a 100 percent interest in the pending application.

II. RELATED APPEALS AND INTERFERENCES

Appellant is unaware of any pending appeals or interferences which may directly affect or be directly affected by, or have a bearing on, the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

The following is a statement of the status of all claims:

Claims 1-107: Rejected under 35 U.S.C. §103(a).

Thus, claims 1-107 remain pending in the present application. A copy of the pending claims involved in this appeal appears in the Claims Appendix of this Brief.

Claims 1-107 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Holder (U.S. 5,588,993) in view of Kamio et al. (U.S. 5,087,429).

The rejection of claims 1-107 under 35 U.S.C. §103(a) is being appealed.

IV. STATUS OF AMENDMENTS

No amendments have been filed after Final Rejection.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The following summary is a concise explanation of the subject matter defined in each independent claim, referring to the specification by page and line number. It correlates claim elements to specific embodiments described in the application specification, but does not in any manner limit claim interpretation. Rather, the following summary is provided only to facilitate the Board's understanding of the subject matter of this appeal.

Claim 1 is directed to a process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method. See page 10, lines 9-20 and page 19, lines 13-28 of the originally filed specification. In one step, a

partially melted charge is formed in the crucible. See page 9, lines 23-27 of the originally filed specification. The partially melted charge comprises molten silicon and unmelted polycrystalline silicon. See page 9, lines 23-27 of the originally filed specification. The molten silicon has an upper surface. See page 9, lines 23-27 of the originally filed specification. The unmelted polycrystalline silicon comprises an exposed portion that is above the upper surface of the molten silicon. See page 9, lines 23-27 of the originally filed specification. In one step, the crucible from which the single crystal silicon ingot is grown is rotated. See page 11, lines 16-18 and page 13, lines 9-15 of the originally filed specification. In one step, additional unmelted polycrystalline silicon is fed into the rotating crucible by intermittently delivering the additional unmelted polycrystalline silicon out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is grown. See page 12, lines 17-21 of the originally filed specification. The intermittent delivery of this step comprises a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted polycrystalline silicon through a feed device that directs the flow of the additional unmelted polycrystalline silicon onto the unmelted polycrystalline silicon of the partially melted charge in the crucible for an on-duration, and each off-period comprises interrupting the flow of the additional unmelted polycrystalline silicon for an off-duration. See page 12, lines 21-28 of the originally filed specification. In one step, the unmelted polycrystalline silicon and the additional unmelted polycrystalline silicon are melted to form the silicon melt in the crucible from which the single crystal silicon ingot is

grown. See page 19, lines 13-26 of the originally filed specification.

Claim 2 is directed to a process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method. See page 10, lines 9-20 and page 19, lines 13-28 of the originally filed specification. In one step, the crucible is loaded with polycrystalline silicon. See page 10, lines 9-20 of the originally filed specification. In one step, the crucible from which the single crystal silicon ingot is grown is rotated. See page 11, lines 16-18 and page 13, lines 9-15 of the originally filed specification. In one step, the loaded polycrystalline silicon is heated to form molten silicon and unmelted polycrystalline silicon. See page 9, lines 29-30 of the originally filed specification. The molten silicon comprises an upper surface. See page 9, lines 23-27 of the originally filed specification. The unmelted polycrystalline silicon comprises an exposed portion that is above the upper surface of the molten silicon. See page 9, lines 23-27 of the originally filed specification. In one step, the additional unmelted polycrystalline silicon is fed into the rotating crucible by intermittently delivering the additional unmelted polycrystalline silicon out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is grown. See page 12, lines 17-21 of the originally filed specification. The intermittent delivery comprises a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted polycrystalline silicon through a feed device that directs the flow of the additional unmelted polycrystalline silicon onto the unmelted polycrystalline

silicon for an on-duration, and each off-period comprises interrupting the flow of the additional unmelted polycrystalline silicon for an off-duration. See page 12, lines 21-28 of the originally filed specification. In one step, the loaded polycrystalline silicon and the additional unmelted polycrystalline silicon are melted to form the silicon melt in the crucible from which the single crystal silicon ingot is grown. See page 19, lines 13-26 of the originally filed specification.

Claim 3 is directed to a process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method. See page 10, lines 9-20 and page 19, lines 13-28 of the originally filed specification. In one step, the crucible is loaded with polycrystalline silicon. See page 10, lines 9-20 of the originally filed specification. The crucible comprises an interior wall and has an inner diameter, *D*. See page 12, lines 4-6 and lines 13-16 of the originally filed specification. In one step, the loaded crucible from which the single crystal silicon ingot is grown is rotated at a rate, *r*. See page 11, lines 16-18 of the originally filed specification. In one step, the loaded polycrystalline silicon is heated to form molten silicon and unmelted polycrystalline silicon. See page 9, lines 29-30 of the originally filed specification. The molten silicon comprises an upper surface. See page 9, lines 23-27 of the originally filed specification. The unmelted polycrystalline silicon comprises an exposed portion that is above the upper surface of the molten silicon. See page 9, lines 23-27 of the originally filed specification. The exposed unmelted polycrystalline has a center and a width, *d*, that corresponds to the longest distance between two points along the interface between the exposed unmelted polycrystalline silicon

and the upper surface of the molten silicon wherein the center of the exposed unmelted polycrystalline is above the interface between the exposed unmelted polycrystalline silicon and the upper surface of the molten silicon. See page 12, lines 11-21 of the originally filed specification. In one step, additional unmelted polycrystalline silicon is fed into the rotating crucible by intermittently delivering the additional unmelted polycrystalline silicon at a feed rate, F, out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is grown, thereby maintaining the width of the exposed unmelted polycrystalline silicon, d. See page 12, line 17 to page 13, line 3 of the originally filed specification. The intermittent delivery comprises a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted polycrystalline silicon at a flow rate, f, for a duration, t_{on}, through a feed device that directs the additional unmelted polycrystalline silicon onto the exposed unmelted polycrystalline silicon, and wherein each off-period comprises interrupting the flow of the additional unmelted polycrystalline silicon through the feed device for a duration, t_{off}. See page 12, lines 21-28 of the originally filed specification. In one step, the loaded polycrystalline silicon and the additional unmelted polycrystalline silicon is melted to form the silicon melt in the crucible from which the single crystal silicon ingot is grown. See page 19, lines 13-26 of the originally filed specification.

Claim 59 is directed to a process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method. See page 10, lines 9-20 and page 19, lines

13-28 of the originally filed specification. In one step, the crucible is loaded with chunk polycrystalline silicon. See page 10, lines 9-20 of the originally filed specification. The amount of the chunk polycrystalline silicon loaded is between about 40% to about 65% by weight of the total amount of the polycrystalline silicon melted to form the silicon melt. See page 11, lines 2-4 of the originally filed specification. In one step, the loaded crucible from which the single crystal silicon ingot is grown is rotated. See page 11, lines 16-18 and page 13, lines 9-15 of the originally filed specification. In one step, the loaded chunk polycrystalline silicon is heated to form molten silicon and unmelted polycrystalline silicon. See page 9, lines 29-30 of the originally filed specification. The molten silicon comprises an upper surface. See page 9, lines 23-27 of the originally filed specification. The unmelted polycrystalline silicon comprises an exposed portion that is above the upper surface of the molten silicon. See page 9, lines 23-27 of the originally filed specification. The exposed unmelted polycrystalline has a center and a width that corresponds to the longest distance between two points along the interface between the exposed unmelted polycrystalline silicon and the upper surface of the molten silicon, the interface between the unmelted polycrystalline silicon and the upper surface of the molten silicon being approximately equidistant from the center of the unmelted polycrystalline silicon. See page 12, lines 11-21 of the originally filed specification. In one step, additional unmelted granular polycrystalline silicon is fed into the rotating crucible by intermittently delivering the additional unmelted granular polycrystalline silicon out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is

grown thereby maintaining the width of the exposed unmelted polycrystalline silicon. See page 12, lines 17-28 and page 12, lines 22-25 of the originally filed specification. The intermittent delivery comprises a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted granular polycrystalline silicon through a feed device that directs the additional unmelted granular polycrystalline silicon onto a wedge of the exposed unmelted polycrystalline silicon that does not substantially overlap with the immediately preceding wedge. See page 12, lines 21-28 and page 17, lines 15-21 of the originally filed specification. Each off-period comprises interrupting the flow of the additional unmelted granular polycrystalline silicon through the feed device. See page 12, lines 21-28 of the originally filed specification. In one step, the loaded polycrystalline silicon and the additional unmelted granular polycrystalline silicon are melted to form the silicon melt in the crucible from which the single crystal silicon ingot is grown. See page 19, lines 13-26 of the originally filed specification.

Claim 60 is directed to a process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method. See page 10, lines 9-20 and page 19, lines 13-28 of the originally filed specification. In one step, the crucible is loaded with chunk polycrystalline silicon. See page 10, lines 9-20 of the originally filed specification. The amount of the chunk polycrystalline silicon loaded is between about 40% to about 65% by weight of the total amount of the polycrystalline silicon melted to form the silicon melt. See page 11, lines 2-4 of the originally filed specification. The crucible comprises an interior wall and has an inner diameter,

D. See page 12, lines 4-6 and lines 13-16 of the originally filed specification. In one step, the loaded crucible from which the single crystal silicon ingot is grown is rotated at a rate, *r*, that ranges from about 1 rpm to about 5 rpm. See page 11, lines 16-18 and page 13, lines 9-15 of the originally filed specification. In one step, the loaded chunk polycrystalline silicon is heated to form molten silicon and unmelted polycrystalline silicon. See page 9, lines 29-30 of the originally filed specification. The molten silicon comprises an upper surface. See page 9, lines 23-27 of the originally filed specification. The unmelted polycrystalline silicon comprises an exposed portion that is above the upper surface of the molten silicon. See page 9, lines 23-27 of the originally filed specification. The exposed unmelted polycrystalline has a center and a width, *d*, that corresponds to the longest distance between two points along the interface between the exposed unmelted polycrystalline silicon and the upper surface of the molten silicon, the interface between the unmelted polycrystalline silicon and the upper surface of the molten silicon being approximately equidistant from the center of the unmelted polycrystalline silicon and approximately equidistance from the interior wall of the crucible. See page 12, lines 11-21 of the originally filed specification. In one step, additional unmelted granular polycrystalline silicon is fed into the rotating crucible by intermittently delivering the additional unmelted granular polycrystalline silicon out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is grown thereby maintaining the width of the exposed unmelted polycrystalline silicon, *d*, at about 65% to about 85% of the crucible diameter, *D*. See page 12, lines 17 to page 13, line 3

of the originally filed specification. The intermittent delivery comprises a plurality of alternating on-periods and off-periods. See page 12, lines 21-28 of the originally filed specification. Each on-period comprises flowing the additional unmelted granular polycrystalline silicon at a flow rate, f, of about 5 g/s to about 35 g/s for duration, t_{on}, of about 2 seconds to about 10 seconds through a feed device that directs the additional unmelted granular polycrystalline silicon onto a wedge of the exposed unmelted polycrystalline silicon. See page 13, lines 15-19 and page 16, lines 9-12 of the originally filed specification. Each wedge has a wedge angle of about 40° to about 72°. See page 16, lines 19-22 of the originally filed specification. Each wedge does not substantially overlap with the immediately preceding wedge. See page 17, lines 15-21 of the originally filed specification. Each off-period comprises interrupting the flow of the additional unmelted granular polycrystalline silicon through the feed device for a duration, t_{off}, of at least about 5 seconds. See page 13, lines 19-22 of the originally filed specification. In one step, the loaded polycrystalline silicon and the additional unmelted granular polycrystalline silicon are melted to form the silicon melt in the crucible from which the single crystal silicon ingot is grown. See page 19, lines 13-26 of the originally filed specification.

Claim 68 is directed to a process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method. See page 10, lines 9-20 and page 19, lines 13-28 of the originally filed specification. In one step, the crucible is rotated at a rate, r. See page 11, lines 16-18 and page 13, lines 9-15 of the originally filed specification. In one step, a depleted molten silicon charge is formed in the

rotating crucible from which the single crystal silicon ingot is grown. See page 21, lines 4-7. The depleted molten silicon charge has a weight, *w*. See page 21, lines 7-12. The crucible comprises an interior wall and has an inner diameter, *D*. See page 12, lines 4-6 and lines 13-16 of the originally filed specification. In one step, polycrystalline silicon is fed into the rotating crucible by delivering the polycrystalline silicon onto the depleted molten silicon charge to form a partial charge comprising molten silicon and unmelted polycrystalline silicon. See page 21, lines 12-15. The molten silicon comprises an upper surface. See page 21, line 15. The unmelted polycrystalline silicon comprises an exposed portion that is above the surface of the molten silicon. See page 21, lines 16-17. The exposed unmelted polycrystalline silicon has a center and width, *d*, that corresponds to the longest distance between two points along the interface between the exposed unmelted polycrystalline silicon and upper surface of the molten silicon. See page 21, lines 17-20. In one step, additional unmelted polycrystalline is fed into the rotating crucible by intermittently delivering the additional unmelted polycrystalline silicon out of a feed tube in the crucible and onto the exposed of said partially melted charge portion of the unmelted polycrystalline silicon in the crucible from which the single crystal silicon ingot is grown thereby maintaining the width of the exposed unmelted polycrystalline silicon, *d*. See page 21, lines 27-30 of the originally filed specification. The intermittent delivery comprises a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional polycrystalline silicon at a flow rate, *f*, for a duration, t_{on}, through a feed device that directs the additional unmelted polycrystalline silicon onto the exposed unmelted polycrystalline silicon, and wherein each off-period comprises

interrupting the flow of the additional unmelted polycrystalline silicon through the feed device for a duration, t_{off}. See page 12, lines 21-28 of the originally filed specification. In one step, the unmelted polycrystalline silicon and the additional unmelted polycrystalline silicon are melted to form the silicon melt in the crucible from which the single crystal silicon ingot is grown. See page 19, lines 13-26 of the originally filed specification.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The only issue presented on appeal is whether the subject matter of claims 1-107 satisfies the requirements of 35 U.S.C. §103(a). Accordingly, appellant appeals the rejection of claims 1-107 as being unpatentable over Holder (U.S. 5,588,993) in view of Kamio et al. (U.S. 5,087,429).

VII. ARGUMENT

For purposes of this appeal, claims 1-107 do not stand or fall together. The claims have been divided into five groups: Group I (claims 1-18, 32-35, 59, 68-76, 85, and 97-102); Group II (claims 19-31, 61, and 77-84); Group III (claims 36-51 and 86-89); Group IV (52-58, 60, 62-67, and 90-96); and Group V (103-107). The claims of each of Groups I, II, III, IV, and V are separately and independently patentable for the reasons described below:

A. Group I: Claims 1-18, 32-35, 59, 68-76, 85, and 97-107 are patentable under 35 U.S.C. §103(a) over Holder (U.S. 5,588,993) in view of Kamio et al. (U.S. 5,087,429)

The Office has taken the position that the Holder reference may be combined with the Kamio et al. reference to reach appellant's claimed process for intermittently supplying umelted polycrystalline silicon to a partially melted silicon melt in a crucible to form a silicon melt. The Office has reached this position by combining Holder, which discloses a method of continuously feeding unmelted polycrystalline silicon into a crucible, with Kamio et al., which discloses a process involving continuous crystal pulling and simultaneous molten silicon replenishment to maintain a constant liquid level in the melt. Kamio et al.'s broad teaching is to a replenishment method involving continuous feeding of silicon. As discussed in more detail below, Kamio et al.'s passing reference to intermittent feeding is in the context of replenishment in a <u>continuous</u> crystal pulling process that employs a <u>constant-height</u> melt. This is a fundamentally different process from the Holder process, which produces a melt <u>batch</u> that is depleted, so the melt height <u>decreases</u> during pulling of an ingot from the melt <u>batchwise</u>. Moreover, Kamio et al.'s background discussion of intermittent feeding is not of <u>un</u>melted polycrystalline silicon, but of a "molten material feeder...thereby intermittently supplying the molten material..."

The Office cannot establish a *prima facie* case of obviousness using the combination of Holder and Kamio et al. under the relevant case law and as reflected in the MPEP because: (1) The person of ordinary skill would not have been motivated to combine the references in the manner suggested by the Office because the processes described in each reference are fundamentally unrelated, (2) The person of ordinary skill would not have been motivated to combine the references in the manner suggested by the Office because intermittent feeding and continuous feeding are not equivalent techniques, and (3) The

combination of references fails to teach or suggest all of the claim limitations.

1. The person of ordinary skill would not have been motivated to combine the references because the processes described in each reference are fundamentally unrelated.

First of all, the processes of Holder and Kamio et al. are fundamentally unrelated such that the person of ordinary skill looking to improve Holder's process would not be motivated to combine it with the proposed aspect of Kamio et al.'s process. As mentioned above, Holder describes a method for continuously feeding granular polycrystalline silicon to form a melt. The melt is completed, i.e., the entire charge is added to the crucible and completely melted, before beginning the single crystal silicon ingot growth process. See Col. 7, lines 11-17 of Holder where Holder states, "After the feeding of granular-polycrystalline silicon 40 is complete, the feed tube 42 can be positioned away from the center of the crucible 20 to allow for crystal pulling." Then, the crystal is pulled and the melt depleted.

Kamio et al. describe a process for continuous feeding of granular silicon during crystal growth to maintain a constant liquid level in the crucible during pulling of the single crystal ingot. Kamio et al. only mention intermittent feeding methods in their background as alternative methods for maintaining a constant liquid level in the crucible, emphasizing that they "have not been put in practical use due to their technical difficulties encountered." Col. 2, lines 10-11.

The person of ordinary skill in the art attempting to improve a process like Holder's process which does not maintain constant liquid levels by replenishment would not see any reason

to employ either of Kamio et al.'s feeding methods, continuous or intermittent. In fact, one skilled in the art working with a continually depleting melt such as Holder's is concerned with creating a melt which is to be depleted. He is not concerned with creating a melt and then maintaining a constant liquid level therein. Accordingly, there is no motivation to combine Holder with any aspect of Kamio et al.'s replenishment process in view of the inapposite fundamental nature of the operations: forming a melt to be depleted (Holder) versus maintaining a melt to be continually replenished and kept at a constant liquid level (Kamio et al.). This is especially true of Kamio et al.'s silicon feeding aspects, since feeding is directly germane to creating and maintaining the melt.

Moreover, neither Holder nor Kamio et al. disclosed any particular reason which would have motivated the person of ordinary skill to change Holder's continuous feeding of granular polycrystalline silicon to an intermittent feeding method. Holder was motivated to provide a method for forming a silicon melt in a crucible from which a single crystal silicon ingot can be pulled with improved zero defect yield. See Holder's abstract. Holder accomplished his goal by continuously feeding granular polycrystalline silicon to the crucible at a relatively slow rate. The relatively slow feed rate allows for long residence time of granular polycrystalline silicon on an unmelted island of silicon in the crucible so that the granular polycrystalline silicon can dehydrogenate. See Col. 5, lines 31-53 and Col. 6, lines 3-11. In Holder's case, there would have been no motivation to periodically shut off feed because the person of ordinary skill would not understand that periodically shutting off the feed would provide any benefit. If anything, the person of ordinary skill in the art would have

thought that periodically shutting off the feed would have unnecessarily slowed the feeding process.

Kamio et al. disclosed no reason to substitute an intermittent feeding method for Holder's continuous feeding. Kamio et al.'s continuous feeding of granular polycrystalline silicon or intermittent feeding of melted silicon during the single crystal silicon ingot growth process maintains constant the liquid level in a melt during the single crystal ingot pulling process. This goal of maintaining a constant liquid level during a simultaneous pulling/feeding operation has nothing to do with Holder's concern of ensuring that unmelted polycrystalline silicon would have enough time to dehydrogenate before melting.

The Office's assertion that "[a] person of ordinary skill in the art would have found it obvious to modify Holder's method of supplying silicon continuous with the known process of intermittently feeding silicon, as taught by Kamio" (see page 6 of the Final Office Action mailed July 14, 2006) is a mere hindsight reconstruction based on appellant's disclosure. Significantly, the disclosure of Kamio et al. was available to Holder and everyone else working in this field for all that it disclosed for 4 years before Holder filed his application. Additionally, both references were available to everyone working in this field for 5 years before appellant filed his application.

Appellant, <u>for the first time</u>, disclosed a method of intermittent feeding of <u>un</u>melted polycrystalline silicon. Moreover, appellant, <u>for the first time</u>, discovered and disclosed a reason for intermittent feeding. Specifically, appellant discovered that intermittent feeding, that is, periodically stopping feeding, can actually decrease the time needed to achieve a complete melt, and thereby increase the

overall feed rate. This unexpected result is counter-intuitive. The person of ordinary skill having the benefit of Holder's disclosure would not have been motivated to periodically shut off feeding because the ordinary artisan would have expected periodic shutoff to slow the feed rate. However, appellant discovered that intermittent feeding reduced the total feed time to "about half the time required for a continuous feeding process." See appellant's Examples 1 and 2, specifically paragraph [0065].

2. The person of ordinary skill would not have been motivated to combine the references because intermittent feeding and continuous feeding are not equivalent techniques.

Second, the Office's assertion that it would have been obvious to modify Holder by using intermittent feeding of unmelted polycrystalline silicon because Kamio et al. show that intermittent feeding is a "known equivalent technique" is incorrect on the facts and not supported by the relevant case law.

The Office has asserted that intermittent feeding and continuous feeding are known equivalents. The Office stated on page 3 in the Office Action mailed Feb. 3, 2006 that "…there are only two types of flow, intermittent and continuous, as evidenced by Kamio et al. and the selection of *one known equivalent technique for another may be obvious* even if the prior art does not expressly suggestion the substitution, *Ex Parte Novak*... ." This is factually and legally deficient because (1) there is no technical support for the assertion that the feeding methods are equivalent, and (2) the *Ex Parte Novak* decision relied on by the Office does not provide the legal support for a conclusion that the two methods are equivalent.

First, there is no technical support for the Office's assertion that the feeding methods are equivalent. Contrary to the Office's assertion, Kamio et al. do not show that the feeding methods are equivalent. They only show that both feeding techniques are capable of feeding melted silicon into a melt to maintain a constant liquid level. Kamio et al. are silent as to the technical effects of each feeding method, beyond the disparaging comment in Col. 2, lines 10-11. The Office appears to base its conclusion of equivalence on the mere citation by Kamio et al. that either of the two feeding methods are capable of maintaining the constant liquid level in a melt.

This is factually incorrect because merely stating that both methods are *capable* does not support a conclusion that they are *equivalent*. Stating that two techniques are capable of achieving a result does not amount to stating they are equivalents anymore than stating that using a flyswatter or bug spray for killing a fly are equivalent techniques. One technique is superior, and, in the present situation, appellant's intermittent feeding of unmelted polycrystalline silicon is superior to the known continuous feeding method. According to *The American Heritage® Dictionary of the English Language, Fourth Edition,* an "equivalent" is "something that is essentially equal to another." As an adjective, "equivalent" means "having similar or identical effects." Accordingly, if intermittent feeding and continuous feeding were equivalent, then they would be essentially equal to each other and have similar or identical effects. They do not. In fact, intermittent feeding is superior in certain aspects to continuous feeding. A person of ordinary skill with the benefit of the disclosure of Holder would recognize that there is a tradeoff between throughput, i.e., the amount of time required to form a melt, and quality, i.e., producing improved zero

defect yield crystals. Holder's continuous feeding method necessitates a relatively low feed rate (low throughput) to achieve improved zero defect yield (high quality). Of course, Holder may increase feed rate (high throughput), but at a cost of lowering the zero defect yield (low quality). Holder chose to lower the feed rate of the continuous feed method. By lowering throughput, Holder achieves an improved zero defect yield. Holder's decision was logical: although a faster throughput is desirable, it is non-productive to produce crystals having higher defect yields, since semiconductor manufacturing requires high quality wafers from high quality single crystal ingots.

Appellant's improved intermittent feeding technique is less burdened by Holder's tradeoff between throughput and quality. Not only can appellant's feeding method improve the zero defect yield (high quality), but *it can do so at a faster rate* (high throughput). For this reason alone, appellant's intermittent feeding method is clearly superior to Holder's continuous feeding method.

The Office has asserted that the feeding techniques are equivalent because "[i]ntermittent and continuous feeding are both capable of supplying silicon at the same rate; therefore have the same effect." See page 7 of the Final Office Action. This is simply wrong for the reasons stated above. Stated simply, Holder's continuous feeding method cannot feed silicon at the same rate as appellant's intermittent feeding method and still achieve the same high quality (i.e., low zero defect yield) ingots achieved by appellant's intermittent feeding method. Perhaps at low feeding rates, both continuous and intermittent feeding may achieve equivalent high quality ingots, but continuous feeding cannot achieve the high quality ingots that intermittent feeding can achieve at high feeding rates.

Second, there is no legal support for the assertion that the feeding methods are equivalent. The Office stated that Kamio et al. show that the methods are equivalent and cited *Ex parte Novak* on pages 3 and 8 of the Office action for the proposition that "…the selection of one known equivalent technique for another may be obvious even if the prior art does not expressly suggestion the substitution."

In *Ex parte Novak*, the "known equivalent techniques" were known. In other words, the steam stripping technique for treating ground coffee and the partial evaporation technique for treating ground coffee at issue in the case were disclosed in the prior art, and Novak merely substituted the one known technique for another known technique. The *Novak* references explicitly discussed the techniques, and the person of ordinary skill in the art could understand, from the references, that the techniques were both applicable for removing volatiles from ground coffee.

This is not the case here because prior to appellant's invention, claim 1's ***intermittent*** feeding of ***unmelted*** polycrystalline silicon was unknown. Holder discloses *continuous* feeding of unmelted polycrystalline silicon. This has been admitted by the Office on page 2 of the Final Office Action, "Holder et al does not teach intermittent feeding." Kamio et al. disclose intermittent or continuous feeding of ***melted*** silicon. See Col. 1, line 68 to Col. 2, line 1, referencing "molten starting material" and Col. 2, lines 4-10 referencing a "molten material feed...thereby intermittently supplying the molted material ...." Neither reference discloses appellant's intermittent feeding of unmelted polycrystalline silicon. Accordingly, the method proposed by the Office to be substituted in for Holder's continuous method cannot fairly be said to be "known." Since the feeding method

is unknown, the present situation is not a *Novak* situation of merely swapping one know technique with another known technique. The Office has failed to show any prior art that discloses intermittent feeding of unmelted polycrystalline silicon.

3. The combination of references fails to teach or suggest all of the claim limitations.

Appellant's claim 1 is further patentable because the combination of references fails to teach or suggest every claim 1 limitation. Appellant's claim 1 was amended in prior Amendment D to clarify that the feeding is "feeding additional **unmelted** polycrystalline silicon into the rotating crucible **by intermittently delivering** the additional **unmelted** polycrystalline silicon..." This amendment underscores an additional distinction between appellant's feeding method and the feeding methods disclosed by Holder and Kamio et al. Specifically, the combination of references does not disclose "feeding additional unmelted polycrystalline silicon…by intermittently delivering…"

Holder does not teach intermittent feeding of unmelted polycrystalline silicon, as conceded by the Office on Page 2 of the Final Office Action mailed July 14, 2006.

The Kamio et al. reference fails to correct this deficiency because it discloses intermittent feeding of ***molten***, (i.e., melted) silicon. The Kamio et al. reference is cited by the Office as disclosing intermittent feeding of silicon, in Cols. 1 and 2 of Kamio et al. In fact, Kamio et al. refer to the Japanese Laid-Open Patent No. 56-164097 as disclosing intermittent feeding. The disclosure of this Laid-Open patent is further detailed in Col. 2, lines 3-11, where it is stated that the

> …single crystal pull apparatus equipped with a ***molten*** material feeder whereby…a powdered sample is temporarily stored ***and melted*** in the forward end of the powdered feed tube thereby ***intermittently supplying the molted*** material into a crucible….

Accordingly, neither Holder nor Kamio et al. disclose "feeding additional ***unmelted*** polycrystalline silicon…by intermittently delivering…" as required by appellant's claim 1.

The foregoing literal distinctions between the respective processes are not simply semantic. Rather, they are germane to the fundamental contrasting goals achieved by the respective processes:

> Appellant's intermittent feeding directly onto the melt to "decrease the amount of time required to prepare a fully molten silicon melt compared to a continuous feeding method" Appellant's specification; paragraph 28.

versus

> Kamio et al.'s [more correctly Laid-Open Patent No. 56-164097] intermittent feeding of molten silicon "…so as to maintain constant the liquid level of the molten material." Kamio et al., Col. 1, lines 55-63.

Moreover, the advantages afforded by intermittent feeding are explained in appellant's specification (paragraph [0046]):

> Experimental results to date suggest that the intermittent feeding process can significantly shorten the feed time compared to a continuous feed process by depositing polycrystalline silicon on the entire exposed unmelted polycrystalline silicon prior to redepositing granular polycrystalline on any wedge.

4. The Group I Claims are Patentable.

In view of all of the foregoing, the Office has failed to establish its *prima facie* case of obviousness with regard to the Group I claims 1-18, 32-35, 59, 68-76, 85, and 97-107 because: (1) The combination of references is not motivated because the

processes described in each reference are fundamentally unrelated, (2) The combination of references is not motivated because intermittent feeding and continuous feeding are not equivalent techniques, and (3) The combination of references fails to teach or suggest all of the claim limitations.

B. Group II: claims 19-31, 61, and 77-84 are patentable under 35 U.S.C. §103(a) over Holder (U.S. 5,588,993) in view of Kamio et al. (U.S. 5,087,429)

The Group II claims 19-31, 60-61, and 77-84, in addition to requiring intermittent feeding of unmelted polycrystalline silicon, define feed parameters f, t_{on}, and t_{off}. As defined by appellant's claim, f is the flow rate during feeding, t_{on} is the duration of feeding, and t_{off} is duration of interrupting feeding.

The Office has taken the position that the Group II claim parameters are obvious because "…the amount of time for commencing and stopping the flow and the flow rate of silicon are result effective variable, which control the thickness of the unmolten layer. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Holder and Kamio et al by optimizing these parameters to obtain same by conducting routine experimentation (MPEP 2144.05)." See pp. 4-5 of the Final Rejection mailed July 14, 2006.

The Office cannot establish a *prima facie* case of obviousness using the combination of Holder and Kamio et al. under the relevant case law and under the Examination guidelines as reflected in the MPEP. The *prima facie* case has not been established because the relevant variables in the Group II claims (I) were not generally known in the prior art and (II)

were not result effective variables amenable to optimization through routine experimentation.

According to the relevant Federal Circuit case law, a parameter or variable must be already generally known in the prior art before it can be asserted that the variable is result effective or amenable to optimization through routine experimentation:

> …see also *Peterson*, 315 F.3d at 1330, 65 USPQ2d at 1382 ("The normal desire of scientists or artisans to improve upon ***what is already generally known*** provides the motivation to determine where in a disclosed set of percentage ranges is the optimum combination of percentages.");… . MPEP 2144.05 Part II (emphasis provided).

In *Peterson*, a *prima facie* obviousness rejection of claims directed to an alloy was upheld over a prior art reference which disclosed an alloy having the same components, wherein the reference's disclosed ranges of wt. % of each component encompassed the claimed ranges of wt.% of each component. Accordingly, the person of ordinary skill in the art, in the *Peterson* case, knew the claimed alloy components and generally the wt. % of each component from the prior art reference.

The threshold recognition, "what is generally known," of the variables described in claims 19-31 is not met in appellant's case because neither Holder nor Kamio et al. recognized the parameters. The Office conceded on page 4 of the Final Office Action that "the combination of Holder and Kamio et al. is silent to the value of the f, t_{on} and t_{off} parameters."

Additionally, the variables in claims 19-31 are unknown in the prior art because the cited references do not even disclose intermittent feeding of unmelted polycrystalline silicon. Since neither the method itself nor the parameters of that method were generally known in the prior art, the person of ordinary skill

was provided no guidance from the cited combination with which to optimize their values.

According to MPEP §2144.05, the prior art must not only generally recognize the variable but must also disclose that it achieves a recognized result:

> A particular parameter must first be recognized as a result-effective variable, i.e., ***a variable which achieves a recognized result***, before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation. *In re Antonie*, 559 F.2d 618, 195 USPQ 6 (CCPA 1977) (The claimed wastewater treatment device had a tank volume to contractor area of 0.12 gal./sq. ft. The prior art did not recognize that treatment capacity is a function of the tank volume to contractor ratio, and therefore the parameter optimized was not recognized in the art to be a result-effective variable.).

In this case, the prior art did not recognize that the time to complete the melt may be shortened and the quality of the single crystal silicon ingots pulled therefrom may be high are functions of the variables f, t_{on}, and t_{off}. Accordingly, these parameters were not recognized in the art to be result-effective. As stated above, in connection with claim 1, the prior art as measured from the Holder and Kamio et al. references only recognized that (1) feeding to form a complete melt by continuous feeding of polycrystalline silicon must be relatively slow to achieve a high quality melt, or (2) intermittent or continuous feeding of unmelted silicon may be used to maintain a constant liquid level in the melt during a simultaneous pulling/replenishing operation. Neither reference recognized any of the advantageous results achieved by appellant in using intermittent feeding of unmelted polycrystalline silicon in which intermittent feeding is defined by the parameters f, t_{on}, and t_{off}.

In view of the foregoing, the Office has failed to establish its *prima facie* case of obviousness with regard to the Group II claims 19-31, 61, and 77-84.

C. Group III: claims 36-51 and 86-89 are patentable under 35 U.S.C. §103(a) over Holder (U.S. 5,588,993) in view of Kamio et al. (U.S. 5,087,429)

The Group III claims 36-51, 60, 86-89, in addition to requiring intermittent feeding of unmelted polycrystalline silicon, define the shape of a wedge on the island of unmelted silicon in the crucible upon which unmelted polycrystalline silicon is fed. The shape of the wedge is defined as a wedge angle.

The Office has taken the position that "…the combination of Holder and Kamio et al. teach rotating at a similar rate and flowing granular silicon intermittently, as applicant, therefore this is inherent to the combination of Holder and Kamio et al. The combination of Holder and Kamio et al also does not teach the wedge angle. The wedge angle is merely the size of the wedge. Changes in size and shape are held to be obvious (MPEP 2144.03)." See page 5 of the final rejection mailed July 14, 2006.

The Office cannot establish a *prima facie* case of obviousness using the combination of Holder and Kamio et al. under the relevant case law and under the Examination guidelines as reflected in the MPEP. The *prima facie* case has not been established because the Office cannot show that the parameters necessary for establishing the wedge shapes defined in the Group III claims are necessarily present in the prior art.

According to MPEP §2112:

> The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or

> characteristic. *In re Rijckaert*, 9 F.3d 1531, 1534, 28 USPQ2d 1955, 1957 (Fed. Cir. 1993) (***reversed rejection because inherency was based on what would result due to optimization of conditions, not what was necessarily present in the prior art***); *In re Oelrich*, 666 F.2d 578, 581-82, 212 USPQ 323, 326 (CCPA 1981). "To establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. ***Inherency, however, may not be established by probabilities or possibilities***. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.' "
>
> In relying on the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that ***the allegedly inherent characteristic necessarily flows from the teaching of the applied prior art.*** (MPEP 2112 (citing Ex parte Levy, 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Inter. 1990))). (emphasis added).

Accordingly, for the claimed wedge shapes as defined by the wedge angles to be deemed to be inherent, the Office must establish by fact or technical reasoning why it is *necessary* that the combination of references would inherently disclose the claimed wedge features.

With regard to the wedge shape, this depends, not only on the factors cited by the examiner, but on all of the following factors:

(1) rotation rate of the crucible

(2) the location of the feed pipe relative to the center of the unmelted polysilicon, such that as the unmelted polysilicon exits the feed pipe it lands on unmelted silicon in the crucible

(3) the direction of flowing unmelted polysilicon as it leaves the opening of the feed pipe

(4) the angle of repose valve

(5) the intermittent flow method

(6) the flow rate while the polysilicon is allowed to flow, f

(7) the duration of the on-periods, t_{on}

(8) the duration of the off-periods, t_{off}.

The Office has conceded the lack of disclosure of at least variables (6) through (8). See page 4 of the Final Rejection mailed July 14, 2006. Since the variables were not disclosed, the size of the wedges can only be established through "probabilities and possibilities," and the Office can only show that the wedge shapes "…may result from a given set of circumstances…" in the prior art. This is expressly forbidden according to the inherency standard outlined in *In re Oelrich*.

Moreover, with respect to variables (6) through (8), the Office on page 5 of the Office Action asserted that these variables could be achieved "…by optimizing these parameters…by conducting routine experimentation." However, according to *In re Rijckaert*, inherency rejections cannot be based on optimization of conditions but on what is necessarily present in the cited art. Accordingly, the Office's assertion that the parameters described in the Group II claims can be optimized by routine experimentation is a concession that the wedge shape requirements of the Group III claims are not *necessarily* present in the cited art under the inherency standard outlined in *Rijckaert*. In other words, if the parameters in the Group II claims may be reached only by optimization through routine experimentation, it necessarily follows that a *prima facie* case against the Group III claims cannot be established under any circumstances because an inherency rejection cannot be based on optimization of conditions, but on what was necessarily present in the prior art.

The Office's position is, essentially, bald speculation that may be characterized, in one sense, as extrapolations of

extrapolations. Therefore, clearly, the Office simply cannot in any way establish a *prima facie* case based on inherent disclosure against the Group III claims.

The Office cited MPEP §2144.04 Parts IV.A. and IV.B for the proposition that the wedge angle is merely the size of the wedge and that changes in size and shape are held to be obvious. These sections of the MPEP are inapposite to this case because these sections deal with scaling up or design considerations. Appellant's wedges are not mere design considerations. Rather, by appropriate selection of values for the eight parameters above to achieve the Group III wedge shapes, appellant has discovered a method of feeding unmelted polycrystalline silicon into a crucible which maximizes throughput without sacrificing quality of the ingot product.

In view of the foregoing, the Office has failed to establish its *prima facie* case of obviousness with regard to the Group III claims 36-51 and 86-89.

D. Group IV claims 52-58, 60, 62-67, and 90-96 are patentable under 35 U.S.C. §103(a) over Holder (U.S. 5,588,993) in view of Kamio et al. (U.S. 5,087,429)

The Group IV claims 53-58, 60, 62-67, 90-96, in addition to requiring intermittent feeding of unmelted polycrystalline silicon, define the positions of the wedges on the island of unmelted silicon in the crucible upon which unmelted polycrystalline silicon is fed. Essentially, the Group IV claims define a pattern of unmelted polycrystalline silicon deposition onto the unmelted exposed silicon surface in the crucible.

The Office has taken the position that "…the combination of Holder and Kamio et al teach rotating at a similar rate and flowing granular silicon intermittently, as applicant, therefore

this is inherent to the combination of...Holder [and Kamio et al.]." See pp. 5-6 of the Final Rejection mailed July 14, 2006.

The arguments stated above for the patentability of the Group III claims apply substantially to the Group IV claims. Briefly, the cited combination cannot inherently disclose the features of the Group IV claims because the references both do not disclose the necessary parameters and the Group IV claim requirements could only be reached by optimization of these non-disclosed parameters.

Moreover, the cited combination of references provides no motivation toward the wedge positions as defined by the Group IV claims. It should be readily apparent that Holder neither discloses nor was at all concerned with patterned flow onto wedges having particular positions on an unmelted silicon island because Holder's deposition was continuous and therefore could not achieve the patterns defined by the Group IV claims.

Kamio et al. do not correct this deficiency because they neither disclose the patterns defined by the Group IV claims nor do they provide any motivation whatsoever to achieve these patterns. Kamio et al. fed melted silicon, intermittently or continuously, with the single purpose of maintaining constant the melt level during a simultaneous pulling/replenishing operation. Accordingly, the rate at which silicon is added is not tethered to the crucible rotation rate, the flow rate, the duration of flow, the duration of termination of flow, or any of the other parameters which dictate the patterns defined by the Group IV claims. Kamio et al.'s flow rate is determined **only** with respect to the rate at which silicon is depleted from the melt and becomes crystallized into the growing silicon ingot. Accordingly, Kamio et al.'s rate of silicon replenishment is completely untethered from any concerns of forming a pattern on an island of unmelted silicon. Since Kamio et al.'s

replenishment rate is singularly determined by the silicon depletion rate from the crucible, Kamio et al. provide no motivation to achieve the pattern of wedges defined in the Group IV claims.

In view of the foregoing, the Office has failed to establish its *prima facie* case of obviousness with regard to the Group IV claims 53-58, 60, 62-67, 90-96.

E. Group V claims 103-107 are patentable under 35 U.S.C. §103(a) over Holder (U.S. 5,588,993) in view of Kamio et al. (U.S. 5,087,429)

The Group V claims 103-107, in addition to requiring intermittent feeding of unmelted polycrystalline silicon, further require pulling an ingot from the silicon melt and leaving a depleted molten silicon charge. The requirements of these claims - pulling an ingot and leaving a depleted charge - underscore a batchwise aspect distinguishing the process from Kamio et al.'s discussion of continuously pulling and intermittently replenishing to maintain a constant liquid level. This renders the Kamio et al. reference even more inapposite to the claimed process. That is, since the Kamio et al. discussion of intermittent feeding relates to continuous ingot pulling and maintaining a constant liquid level, there is no basis to apply this teaching to batchwise ingot pulling, i.e., "pulling an ingot [from the melt] and thereby leaving a depleted molten silicon charge" as required by the Group V claims. These claims are therefore non-obvious over the cited combination for this reason, in addition to the reasons stated above in connection with the Group I claims.

VIII. CONCLUSION

In view of the foregoing, appellant respectfully requests that the Office's rejection of claims 1-107 be reversed and that claims 1-107 be allowed.

Respectfully submitted,

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IX. CLAIMS APPENDIX

1. (Previously Presented) A process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method, the process comprising:

a. forming a partially melted charge in the crucible, the partially melted charge comprising molten silicon and unmelted polycrystalline silicon, the molten silicon having an upper surface, the unmelted polycrystalline silicon comprising an exposed portion that is above the upper surface of the molten silicon;

b. rotating the crucible from which the single crystal silicon ingot is grown;

c. feeding additional unmelted polycrystalline silicon into the rotating crucible by intermittently delivering the additional unmelted polycrystalline silicon out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is grown, the intermittent delivery comprising a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted polycrystalline silicon through a feed device that directs the flow of the additional unmelted polycrystalline silicon onto the unmelted polycrystalline silicon of the partially melted charge in the crucible for an on-duration, and each off-period comprises interrupting the flow of the additional unmelted polycrystalline silicon for an off-duration; and

d. melting the unmelted polycrystalline silicon and the additional unmelted polycrystalline silicon to form the silicon melt in the crucible from which the single crystal silicon ingot is grown.

2. (Previously Presented) A process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method, the process comprising:

a. loading the crucible with polycrystalline silicon;

b. rotating the loaded crucible from which the single crystal silicon ingot is grown;

c. heating the loaded polycrystalline silicon to form molten silicon and unmelted polycrystalline silicon, the molten silicon comprising an upper surface, the unmelted polycrystalline silicon comprising an exposed portion that is above the upper surface of the molten silicon;

d. feeding additional unmelted polycrystalline silicon into the rotating crucible by intermittently delivering the additional unmelted polycrystalline silicon out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is grown, the intermittent delivery comprising a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted polycrystalline silicon through a feed device that directs the flow of the additional unmelted polycrystalline silicon onto the unmelted polycrystalline silicon for an on-duration, and each

off-period comprises interrupting the flow of the additional unmelted polycrystalline silicon for an off-duration; and

e. melting the loaded polycrystalline silicon and the additional unmelted polycrystalline silicon to form the silicon melt in the crucible from which the single crystal silicon ingot is grown.

3. (Previously Presented) A process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method, the process comprising:

a. loading the crucible with polycrystalline silicon, the crucible comprising an interior wall and having an inner diameter, *D;*

b. rotating the loaded crucible from which the single crystal silicon ingot is grown at a rate, *r;*

c. heating the loaded polycrystalline silicon to form molten silicon and unmelted polycrystalline silicon, the molten silicon comprising an upper surface, the unmelted polycrystalline silicon comprising an exposed portion that is above the upper surface of the molten silicon, the exposed unmelted polycrystalline having a center and a width, *d*, that corresponds to the longest distance between two points along the interface between the exposed unmelted polycrystalline silicon and the upper surface of the molten silicon wherein the center of the exposed unmelted polycrystalline is above the interface between the exposed unmelted polycrystalline silicon and the upper surface of the molten silicon;

d. feeding additional unmelted polycrystalline silicon into the rotating crucible by intermittently delivering the additional unmelted polycrystalline silicon at a feed rate, F, out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is grown, thereby maintaining the width of the exposed unmelted polycrystalline silicon, d, the intermittent delivery comprising a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted polycrystalline silicon at a flow rate, f, for a duration, t_{on}, through a feed device that directs the additional unmelted polycrystalline silicon onto the exposed unmelted polycrystalline silicon, and wherein each off-period comprises interrupting the flow of the additional unmelted polycrystalline silicon through the feed device for a duration, t_{off}; and

e. melting the loaded polycrystalline silicon and the additional unmelted polycrystalline silicon to form the silicon melt in the crucible from which the single crystal silicon ingot is grown.

4. (Original) The process as set forth in claim 3 wherein the interface between the unmelted polycrystalline silicon and the upper surface of the molten silicon is approximately equidistant from the center of the unmelted polycrystalline silicon.

5. (Original) The process as set forth in claim 4 wherein the interface between unmelted polycrystalline silicon and the

upper surface of the molten silicon is approximately equidistant from the interior wall of the crucible.

6. (Previously Presented) The process as set forth in claim 5 wherein the polycrystalline silicon that is loaded into the crucible is chunk polycrystalline silicon and the additional unmelted polycrystalline silicon fed into the crucible is granular polycrystalline silicon.

7. (Original) The process as set forth in claim 6 wherein the loaded chunk polycrystalline silicon comprises about 40% to about 65% by weight of the silicon melt.

8. (Original) The process as set forth in claim 6 wherein the loaded chunk polycrystalline silicon comprises about 50% to about 60% by weight of the silicon melt.

9. (Original) The process as set forth in claim 6 wherein d ranges from about 65% to about 85% of D.

10. (Original) The process as set forth in claim 6 wherein d is about 75% of D.

11. (Original) The process as set forth in claim 6 wherein r is at least about 1 rpm.

12. (Original) The process as set forth in claim 6 wherein r ranges from about 1 rpm to about 5 rpm.

13. (Original) The process as set forth in claim 6 wherein r ranges from about 2 rpm to about 3 rpm.

14. (Original) The process as set forth in claim 6 wherein r is about 2.1 rpm.

15. (Original) The process as set forth in claim 6 wherein F is at least about 1 kg/hr.

16. (Original) The process as set forth in claim 6 wherein F ranges from about 1.5 kg/hr to about 65 kg/hr.

17. (Original) The process as set forth in claim 6 wherein F ranges from about 5 kg/hr to about 30 kg/hr.

18. (Original) The process as set forth in claim 6 wherein F ranges from about 10 kg/hr to about 20 kg/hr.

19. (Original) The process as set forth in claim 6 wherein f is at least about 1 g/s.

20. (Original) The process as set forth in claim 6 wherein f ranges from about 5 g/s to about 35 g/s.

21. (Original) The process as set forth in claim 6 wherein f ranges from about 10 g/s to about 25 g/s.

22. (Original) The process as set forth in claim 6 wherein t_{on} is at least about 1 second.

23. (Original) The process as set forth in claim 6 wherein t_{on} ranges from about 2 seconds to about 10 seconds.

24. (Original) The process as set forth in claim 6 wherein t_{on} ranges from about 4 seconds to about 10 seconds.

25. (Original) The process as set forth in claim 6 wherein t_{on} is about 5 seconds.

26. (Original) The process as set forth in claim 6 wherein t_{off} is at least about 1 second.

27. (Original) The process as set forth in claim 6 wherein t_{off} is at least about 5 seconds.

28. (Original) The process as set forth in claim 6 wherein t_{off} ranges from about 10 seconds to about 30 seconds.

29. (Original) The process as set forth in claim 6 wherein t_{off} ranges from about 10 seconds to about 20 seconds.

30. (Original) The process as set forth in claim 6 wherein t_{off} ranges from about 10 seconds to about 15 seconds.

31. (Original) The process as set forth in claim 6 wherein t_{off} is about 12 seconds.

32. (Original) The process as set forth in claim 6 wherein the flow of the granular polycrystalline silicon is interrupted during the off-period using an angle of repose valve.

33. (Original) The process as set forth in claim 6 wherein the feed device directs the granular polycrystalline silicon onto a portion of the exposed unmelted polycrystalline.

34. (Original) The process as set forth in claim 33 wherein the feed device through which the granular

polycrystalline silicon is flowed is a vertical-type feed tube that is positioned so that it is not directly above the center of the exposed unmelted polycrystalline silicon.

35. (Original) The process as set forth in claim 33 wherein the feed device through which the granular polycrystalline silicon is flowed is a spray-type feed tube.

36. (Original) The process as set forth in claim 33 wherein the portion of the exposed unmelted polycrystalline upon which the granular polycrystalline silicon is delivered is a wedge that extends radially outward from about the center to the interface between the unmelted polycrystalline silicon and the upper surface of the molten silicon.

37. (Original) The process as set forth in claim 36 wherein the wedge has a wedge angle that is about 180°.

38. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is less than about 180°.

39. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 120°.

40. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is less than about 120°.

41. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 90°.

42. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is less than about 90°.

43. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that ranges from about 40° to about 72°.

44. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 72°.

45. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 60°.

46. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 51.4°.

47. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 45°.

48. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 40°.

49. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 36°.

50. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 30°.

51. (Original) The process as set forth in claim 33 wherein the wedge has a wedge angle that is about 27.7°.

52. (Original) The process as set forth in claim 33 wherein each wedge on the exposed unmelted polycrystalline silicon does not substantially overlap with the immediately preceding wedge.

53. (Original) The process as set forth in claim 52 wherein granular polycrystalline silicon is deposited on the entire exposed unmelted polycrystalline silicon prior to redepositing granular polycrystalline silicon on any wedge.

54. (Original) The process as set forth in claim 53 wherein each subsequent wedge is deposited adjacent to the immediately preceding wedge and within one rotation of the crucible after the immediately preceding wedge.

55. (Original) The process as set forth in claim 53 wherein each subsequent wedge is deposited adjacent to the immediately preceding wedge and following at least one rotation of the crucible after the immediately preceding wedge.

56. (Original) The process as set forth in claim 53 wherein each subsequent wedge is deposited nearly opposite from the immediately preceding wedge, and adjacent to the second-most recent wedge and within one rotation of the crucible after the second-most recent wedge.

57. (Original) The process as set forth in claim 53 wherein each subsequent wedge is deposited nearly opposite from the immediately preceding wedge, and adjacent to the second-most recent wedge and following at least one rotation of the crucible after the second-most recent wedge.

58. (Original) The process as set forth in claim 52 wherein granular polycrystalline silicon is redeposited on a wedge prior to the depositing granular polycrystalline silicon on the entire exposed unmelted polycrystalline silicon.

59. (Previously Presented) A process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grow from polycrystalline silicon for use in growing the single crystal silicon ingot by the Czochralski method, the process comprising:

a. loading the crucible with chunk polycrystalline silicon, the amount of the chunk polycrystalline silicon load being between about 40% to about 65% by weight of the total amount of the polycrystalline silicon melted to form the silicon melt;
b. rotating the loaded crucible from which the single crystal silicon ingot is grown;
c. heating the loaded chunk polycrystalline silicon to form molten silicon and unmelted polycrystalline silicon, the molten silicon comprising an upper surface, the unmelted polycrystalline silicon comprising an exposed portion that is above the upper surface of the molten silicon, the exposed unmelted polycrystalline having a center and a width that corresponds to the longest distance between two points along the interface between the exposed unmelted polycrystalline silicon and the upper surface of the molten silicon, the interface between the unmelted polycrystalline silicon and the upper surface of the molten silicon being approximately equidistant from the center of the unmelted polycrystalline silicon;

d. feeding additional unmelted granular polycrystalline silicon into the rotating crucible by intermittently delivering the additional unmelted granular polycrystalline silicon out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted charge in the crucible from which the single crystal silicon ingot is grown thereby maintaining the width of the exposed unmelted polycrystalline silicon, the intermittent delivery comprising a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted granular polycrystalline silicon through a feed device that directs the additional unmelted granular polycrystalline silicon onto a wedge of the exposed unmelted polycrystalline silicon that does not substantially overlap with the immediately preceding wedge, and wherein each off-period comprises interrupting the flow of the additional unmelted granular polycrystalline silicon through the feed device; and

e. melting the loaded polycrystalline silicon and the additional unmelted granular polycrystalline silicon to form the silicon melt in the crucible from which the single crystal silicon ingot is grown.

60. (Previously Presented) A process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown from polycrystalline silicon for use in growing the single crystal silicon ingot by the Czochralski method, the process comprising:

a. loading the crucible with chunk polycrystalline silicon, the amount of the chunk polycrystalline silicon load being between about 40% to about 65% by weight of the total amount of the polycrystalline silicon melted to form the silicon melt, the crucible comprising an interior wall and having an inner diameter, *D;*

b. rotating the loaded crucible from which the single crystal silicon ingot is grown at a rate, *r*, that ranges from about 1 rpm to about 5 rpm;

c. heating the loaded chunk polycrystalline silicon to form molten silicon and unmelted polycrystalline silicon, the molten silicon comprising an upper surface, the unmelted polycrystalline silicon comprising an exposed portion that is above the upper surface of the molten silicon, the exposed unmelted polycrystalline having a center and a width, *d*, that corresponds to the longest distance between two points along the interface between the exposed unmelted polycrystalline silicon and the upper surface of the molten silicon, the interface between the unmelted polycrystalline silicon and the upper surface of the molten silicon being approximately equidistant from the center of the unmelted polycrystalline silicon and approximately equidistance from the interior wall of the crucible;

d. feeding additional unmelted granular polycrystalline silicon into the rotating crucible by intermittently delivering the additional unmelted granular polycrystalline silicon out of a feed tube in the crucible and onto the exposed portion of the unmelted polycrystalline silicon of said partially melted

charge in the crucible from which the single crystal silicon ingot is grown thereby maintaining the width of the exposed unmelted polycrystalline silicon, d, at about 65% to about 85% of the crucible diameter, D, the intermittent delivery comprising a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional unmelted granular polycrystalline silicon at a flow rate, f, of about 5 g/s to about 35 g/s for duration, t_{on}, of about 2 seconds to about 10 seconds through a feed device that directs the additional unmelted granular polycrystalline silicon onto a wedge of the exposed unmelted polycrystalline silicon wherein each wedge has a wedge angle of about 40° to about 72° and each wedge does not substantially overlap with the immediately preceding wedge, and wherein each off-period comprises interrupting the flow of the additional unmelted granular polycrystalline silicon through the feed device for a duration, t_{off}, of at least about 5 seconds; and

e. melting the loaded polycrystalline silicon and the additional unmelted granular polycrystalline silicon to form the silicon melt in the crucible from which the single crystal silicon ingot is grown.

61. (Original) The process as set forth in claim 60 wherein d is about 75% of D, r ranges from about 2 rpm to about 3 rpm, f ranges from about 10 g/s to 25 g/s, t_{on} ranges from about 4 seconds to about 10 seconds, and t_{off} ranges from about 10 seconds to about 30 seconds.

62. (Previously Presented) The process as set forth in claim 60 wherein unmelted granular polycrystalline silicon is deposited on the entire exposed unmelted polycrystalline silicon prior to redepositing unmelted granular polycrystalline on any wedge.

63. (Original) The process as set forth in claim 62 wherein each subsequent wedge is deposited adjacent to the immediately preceding wedge and within one rotation of the crucible after the immediately preceding wedge.

64. (Original) The process as set forth in claim 62 wherein each subsequent wedge is deposited adjacent to the immediately preceding wedge and following at least one rotation of the crucible after the immediately preceding wedge.

65. (Original) The process as set forth in claim 62 wherein each subsequent wedge is deposited nearly opposite from the immediately preceding wedge, and adjacent to the second-most recent wedge and within one rotation of the crucible after the second-most recent wedge.

66. (Original) The process as set forth in claim 62 wherein each subsequent wedge is deposited nearly opposite from the immediately preceding wedge, and adjacent to the second-most recent wedge and following at least one rotation of the crucible after the second-most recent wedge.

67. (Previously Presented) The process as set forth in claim 60 wherein the additional unmelted granular polycrystalline silicon is redeposited on a wedge prior to the

depositing the additional unmelted granular polycrystalline silicon on the entire exposed unmelted polycrystalline silicon.

68. (Previously Presented) A process for preparing a silicon melt in a crucible from which a single crystal silicon ingot is grown for use in growing the single crystal silicon ingot by the Czochralski method, the process comprising:

a. rotating the crucible at a rate, *r;*

b. forming a depleted molten silicon charge in the rotating crucible from which the single crystal silicon ingot is grown, the depleted molten silicon charge having a weight, *w*, the crucible comprising an interior wall and having an inner diameter, *D;*

c. feeding polycrystalline silicon into the rotating crucible by delivering the polycrystalline silicon onto the depleted molten silicon charge to form a partial charge comprising molten silicon and unmelted polycrystalline silicon, the molten silicon comprising an upper surface, the unmelted polycrystalline silicon comprising an exposed portion that is above the surface of the molten silicon, the exposed unmelted polycrystalline silicon having a center and width, *d*, that corresponds to the longest distance between two points along the interface between the exposed unmelted polycrystalline silicon and upper surface of the molten silicon;

d. feeding additional unmelted polycrystalline into the rotating crucible by intermittently delivering the additional unmelted polycrystalline silicon out of a feed tube in the crucible and onto the exposed of said partially melted charge portion of the unmelted polycrystalline silicon in the crucible from which the

single crystal silicon ingot is grown thereby maintaining the width of the exposed unmelted polycrystalline silicon, *d*, the intermittent delivery comprising a plurality of alternating on-periods and off-periods, wherein each on-period comprises flowing the additional polycrystalline silicon at a flow rate, *f*, for a duration, t_{on}, through a feed device that directs the additional unmelted polycrystalline silicon onto the exposed unmelted polycrystalline silicon, and wherein each off-period comprises interrupting the flow of the additional unmelted polycrystalline silicon through the feed device for a duration, t_{off}; and

e. melting the unmelted polycrystalline silicon and the additional unmelted polycrystalline silicon to form the silicon melt in the crucible from which the single crystal silicon ingot is grown.

69. (Original) The process as set forth in claim 68 wherein *w* is about 15% to about 40% by weight of the silicon melt.

70. (Original) The process as set forth in claim 68 wherein *w* is about 20% to about 30% by weight of the silicon melt.

71. (Original) The process as set forth in claim 68 wherein the interface between the unmelted polycrystalline silicon and the upper surface of the molten silicon is approximately equidistant from the center of the unmelted polycrystalline silicon and approximately equidistant from the interior wall of the crucible.

72. (Previously Presented) The process as set forth in claim 71 wherein the polycrystalline silicon and the additional unmelted polycrystalline silicon fed into the crucible are granular polycrystalline silicon.

73. (Original) The process as set forth in claim 72 wherein d ranges from about 65% to about 85% of D.

74. (Original) The process as set forth in claim 72 wherein d is about 75% of D.

75. (Original) The process as set forth in claim 73 wherein r ranges from about 1 rpm to about 5 rpm.

76. (Original) The process as set forth in claim 73 wherein r ranges from about 2 rpm to about 3 rpm.

77. (Original) The process as set forth in claim 75 wherein f ranges from about 5 g/s to about 35 g/s.

78. (Original) The process as set forth in claim 75 wherein f ranges from about 10 g/s to about 25 g/s.

79. (Original) The process as set forth in claim 77 wherein t_{on} ranges from about 2 seconds to about 10 seconds.

80. (Original) The process as set forth in claim 77 wherein t_{on} ranges from about 4 seconds to about 10 seconds.

81. (Original) The process as set forth in claim 79 wherein t_{off} is at least about 5 seconds.

82. (Original) The process as set forth in claim 79 wherein t_{off} ranges from about 10 seconds to about 30 seconds.

83. (Original) The process as set forth in claim 79 wherein t_{off} ranges from about 10 seconds to about 20 seconds.

84. (Original) The process as set forth in claim 79 wherein t_{off} ranges from about 10 seconds to about 15 seconds.

85. (Original) The process as set forth in claim 81 wherein the feed device directs the granular polycrystalline silicon onto a portion of the exposed unmelted polycrystalline.

86. (Original) The process as set forth in claim 85 wherein the portion of the exposed unmelted polycrystalline silicon upon which the granular polycrystalline silicon is delivered is a wedge that extends radially outward from about the center to the interface between the unmelted polycrystalline silicon and the upper surface of the molten silicon.

87. (Original) The process as set forth in claim 86 wherein the wedge has a wedge angle that is less than about 180°.

88. (Original) The process as set forth in claim 86 wherein the wedge has a wedge angle that ranges from about 40° to about 72°.

89. (Original) The process as set forth in claim 86 wherein the wedge has a wedge angle that is about 60°, or 51.4°, or 45°, or 40°, or 36°, or 30° or 27.7°.

90. (Original) The process as set forth in claim 86 wherein each wedge on the exposed unmelted polycrystalline silicon does not substantially overlap with the immediately preceding wedge.

91. (Original) The process as set forth in claim 90 wherein granular polycrystalline silicon is deposited on the entire exposed unmelted polycrystalline silicon prior to redepositing granular polycrystalline silicon on any wedge.

92. (Original) The process as set forth in claim 91 wherein each subsequent wedge is deposited adjacent to the immediately preceding wedge and within one rotation of the crucible after the immediately preceding wedge.

93. (Original) The process as set forth in claim 91 wherein each subsequent wedge is deposited adjacent to the immediately preceding wedge and following at least one rotation of the crucible after the immediately preceding wedge.

94. (Original) The process as set forth in claim 91 wherein each subsequent wedge is deposited nearly opposite from the immediately preceding wedge, and adjacent to the second-most recent wedge and within one rotation of the crucible after the second-most recent wedge.

95. (Original) The process as set forth in claim 91 wherein each subsequent wedge is deposited nearly opposite from the immediately preceding wedge, and adjacent to the second-most recent wedge and following at least one rotation of the crucible after the second-most recent wedge.

96. (Original) The process as set forth in claim 90 wherein granular polycrystalline silicon is redeposited on a wedge prior to the depositing granular polycrystalline silicon on the entire exposed unmelted polycrystalline silicon.

97. (Previously presented) The process as set forth in claim 1 further comprising growing a single crystal silicon ingot by the Czochralski method from the silicon melt in the crucible.

98. (Previously presented) The process as set forth in claim 2 further comprising growing a single crystal silicon ingot by the Czochralski method from the silicon melt in the crucible.

99. (Previously presented) The process as set forth in claim 3 further comprising growing a single crystal silicon ingot by the Czochralski method from the silicon melt in the crucible.

100. (Previously presented) The process as set forth in claim 59 further comprising growing a single crystal silicon ingot by the Czochralski method from the silicon melt in the crucible.

101. (Previously presented) The process as set forth in claim 60 further comprising growing a single crystal silicon ingot by the Czochralski method from the silicon melt in the crucible.

102. (Previously presented) The process as set forth in claim 68 further comprising growing a single crystal silicon ingot by the Czochralski method from the silicon melt in the crucible.

103. (Previously presented) The process as set forth in claim 1 further comprising the step of pulling an ingot therefrom and thereby leaving a depleted molten silicon charge.

104. (Previously presented) The process as set forth in claim 2 further comprising the step of pulling an ingot therefrom and thereby leaving a depleted molten silicon charge.

105. (Previously presented) The process as set forth in claim 3 further comprising the step of pulling an ingot therefrom and thereby leaving a depleted molten silicon charge.

106. (Previously presented) The process as set forth in claim 59 further comprising the step of pulling an ingot therefrom and thereby leaving a depleted molten silicon charge.

107. (Previously presented) The process as set forth in claim 60 further comprising the step of pulling an ingot therefrom and thereby leaving a depleted molten silicon charge.

X. EVIDENCE APPENDIX

None.

XI. RELATED PROCEEDINGS APPENDIX

None.